J. Glob. Innov. Agric. Soc. Sci., 2017, 5(3): 130-136
ISSN (Online): 2311-3839; ISSN (Print): 2312-5225
http://www.jgiass.com

# RESPONSE OF *Eucalyptus camaldulensis* AND *Eucalyptus globulus* SEEDLINGS TO DIFFERENT LEVELS OF SALINITY

**Muhammad Akram[1,*], Muhammad Ayyub Tanvir[1], Muhammad Tahir Siddiqui[1], Mobushir Iqbal[2] and Muhammad Qayyum[2]**

**[1]Institute of Forestry and Range Management, University of Agriculture Faisalabad, Pakistan;**
**[2]Institute of Agricultural Extension & Rural Development (IAERD), University of Agriculture, Faisalabad, Pakistan**
***Corresponding author's e-mail: khanakram11223@gmail.com**

Eucalyptus camaldulensis and Eucalyptus globulus are well known tree species for producing pulp. Pulp is usually obtained from Eucalyptus species globally because of its excellent production of pulp with low lignin content. The Eucalyptus is a species that have maximum rate of production and we can grow this species worldwide for betterment of climate and other products like construction limber, pulp, fuelwood, oil and coal. In Pakistan, arid and semi-arid areas are the most important for this species because Eucalyptus species aredrought and salinity tolerant. Eucalyptus camaldulensis is a very quick responding tree specie that produces huge amount of biomass in short time span. However, this species is disliked by the farmers because of its outstanding potential for high rate of transpiration. Thus, pulp production in Pakistan is yet a dream in present water deficient scenario. In this context, exploring some alternate species that may exhaust relatively less water from underground water table is highly demanded under such circumstances. Therefore, present study was designed to evaluate the growth potential of Eucalyptus camaldulensis and Eucalyptus globulus under saline conditions. Healthy and uniform sized seeds were collected from Pakistan Forest Research Institute (PFRI) Faisalabad. Firstly, the selected seeds were sown in polythene bags and after six weeks of germination, three groups of seedlings were shifted in pots to treat them with three different level of salinity (EC), three types of NaCl loaded irrigation water were applied to the seedlings as: 1-T0 (no NaCl addition to irrigation water), 2-T1 (Irrigation water of 8 EC), 3-T2 (Irrigation water of 12 EC). There were 6 plants of each species per treatment per replication. Thus, total number of experimental seedlings were (species × number of plants × treatment × replication) 108. The seedlings were monitored for growth behavior for the period of six months. Various growth parameters were measured during the experiment. Results showed that biomass production such as plant height, fresh and dry weight of roots were highly affected under high saline soil of both species. Root growth pattern of both species were different. Eucalyptus camaldulensis developed longer roots under stress comparable to control plants whereas in the case of E. globulus an increased root biomass was observed with more lateral root growth than vertical growth. Eucalyptus camaldulensis was the more salt tolerance than Eucalyptus globulus. However successful establishment of Eucalyptus globulus in water deficient conditions may be a good alternate option to replace Eucalyptus camaldulensis as agro-forest tree for pulp production.
**Keywords:** Respnse, Globulus, Eucalypus, Germination, Treatment, Pulp production

## INTRODUCTION

Forests provide a wide range of goods and services to the local people and about 1 billion of the world's poor depend on forest resources for their livelihoods. Forests play a vital role to support rural life as they provide basic needs of living with pure oxygen (Nowak *et al.*, 2001). They make natural to available resources to city areas where now 80% approximately US population lives. Due to the increasing population, urbanization and industrialization, our forests are under extreme pressure and it is very difficult for flora and fauna to keep themselves with their basic ecological services including cleaning air and water purification, carbon sequestration (Scherr *et al.*, 2003).

Presently, public forests of Pakistan contribute only 10% of fuel wood and just 14% of the commercial timber. Farm grown wood provides 90% fuel wood and 65-70% of timber wood requirements (Mohyuddin, 2007). The remaining 15-20% of timber requirement is being fulfilled by the import of wood and wood products (Ahmad, 2005; Khan, 2000) and Rs. 9163.9 million per annum is being spent on the import of wood and wood products. The total demand of wood in the year 2000 was 844600 $m^3$ and the contribution of *Eucalyptus camaldulensis* and *Eucalyptus globulus* to fulfill the gap was 61% i.e., 5191000 $m^3$ (Khan and Khan, 2001).

Pakistan being an agricultural country containing 25% of total area under crops. But, forest has fairly small part which is about 4.8% while, the recommended ratio for balanced economic expansion and environmental constancy of the country is 20-25% (Quraishi, 2000).

*Eucalyptus* is a fast growing tree whose wood is the main raw material for pulp production in Southwest Europe, Brazil, South Africa, and other countries. It is the largest single global source of market pulp and its use for pulp production has

greatly increased during last decades and the exported world pulp production is nearly 20 million tons per year which is about 60% of the total hardwood pulp produced (Trabado and Wilstermann, 2008).

Manufacturing and consumption of paper pulp are continuously growing across the world. Pulp and paper sectors have a large trading set up in Spain and Spain holds the 5th position as cellulose producer among European countries with a national production of 2.0 and 6.4 million tons of pulp and paper in 2006, respectively (Antunes *et al.* 2000: Espaola *et al.* 2006).

*Eucalyptus* pulp is getting the dominant position in the world of hardwood pulp market. The actual production of such pulp is 10 million tons per year, with an annual increment of 6 percent. Some countries are using birch wood for pulp production, however, pulp production from its wood is inexpensive because of its high growth rate and high pulp yield (Patt *et al.*2004).

Saline soil is a major problem in many productive agriculture areas of Pakistan. Deforestation has been examined as a major cause of salinity in many land areas. So, it has been concluded that the trees are the major source for controlling salinity (Farrington and Bartle, 2009). Many studied has been conducted to test salinity on different tree species. Some Australian tree species from the *Eucalyptus* genera, Acacia and Meluleucu have been examined to be salt-tolerant and are planted greatly in other countries also (Midgley *et al.,* 2004). However, Pakistan is water deficient country. Thus, we need to promote such species that may be exposed drought resistant tree species and *Eucalyptus camaldulensis* performs well in saline and water logged conditions. It can also grow fast during the hot, dry summer period. Thus, it may be a potential alternative sources to *E. camaldulensis* (Ashraf *et al.*, 2012).

*Eucalyptus globulus* grows rapidly under moderate water stress. Physiological characteristics that facilitates this growth include maintenance of a high leaf area to sapwood area ratio and relatively high leaf conductance during drought. These traits render *E.globulus* vulnerable to prolonged or extreme water stress (Zekri, 2008).

Since our country is water deficient, therefore, *Eucalyptus globulus* can be flourished successfully in such conditions. In this response *Eucalyptus camaldulensis* and *Eucalyptus globulus* were tested under different levels of salinity and comparison growth pattern of both species. Keeping in view the background considerations, an experiment was conducted with following objectives:

- To test comparative response of *Eucalyptus globulus* and *Eucalyptus camaldulensis* under similar saline condition.
- To know the effect of NaCl on the growth of *Eucalyptus camadulensis* and *Eucalyptus galobulus* seedlings.

## MATERIALS AND METHODS

The present study was designed to evaluate the growth potential of *Eucalyptus camaldulensis* and *Eucalyptus globulus* under saline conditions.

In many plants Sprouting and the growth of seedling are the most sensitive stages to salinity effect. The current study was scheduled on *Eucalyptus* seedlings which were treated with salinity effect. The main objective of this study was to screen and relate the *Eucalyptus camaldulensis and Eucalyptus globulus* performance under salinity stress.

### Plant Collection and Layout

***Experimental site*****:** Experiment was carried out under natural condition in the Forest Nursery and Experimental Area, Department of Forestry and Range Management University of Agriculture Faisalabad during the year 10-02-2016 to 10-08-2016.

***Seed Collection*****:** For the trial, well ripened, uniform sized and open pollinated seeds *of E. camaldulensis* and *E. globulus* were collected from Pakistan Forest Research Institute (PFRI) Guttwala, Faisalabad.

***Soil media*****:** Homogeneous soil medium (silt loam “Bhal” available from de-silting of river-fed canal banks) was used. This silt soil was collected from Forest Nursery and Experimental Area, Department of Forestry and Range Management University of Agriculture Faisalabad. Plant debris and other deadly material were removed from the soil. The air dried soil was filtered and mixed thoroughly.

***Plastic trays preparation*****:** Four plastic trays (15″×9″×3″) were filled with soil media as mentioned above. Seeds were sown in the plastic trays. Seeds were sown manually 1cm depth of soil in plastic trays. Before felling a tray with soil media a plastic sheet was spread in the trays. Some whole (1cm dia) were made in the sheet at the spacing of 6"×6" to support water drainage and to maintain moisture up to field capacity. The plastic trays were placed under shade of the polythene sheet to maintain high humidity and ambient temperature to enhance seed germination. Ground water was applied once after two days to each tray continuously. Seeds started to germinate within two weeks of sowing.

***Experimental condition*****:** This experiment was conducted in net house Forest nursery, Department of Forestry and Range Management. The net house was covered with green net from its roof to avoid direct exposure of experimental plants to intensive sunlight. There was no air restriction as its sides were opened. However, the plants were strictly protected from rain fall water. These conditions were maintained throughout the experimental duration.

***Transplanting*****:** After germination two month-old seedlings were transplanted into earthen pots. The ground water was applied twice on daily basis after transplanting the plants. All individuals were distributed randomly in the field plot (2 species; 108 plants, with one plant per pot).

***Tunnel and Earthen pots preparation*:** I collected 108 earthen pots from Evergreen Nursery, Near Institute of Cardiology, Kachahri Chowk Faisalabad. The size of earthen pots was (10″ × 5″) in which 3 kg soil media was filled. Then these earthen pots were placed into the plastic tunnel. The tunnel size was 18.5 × 23.5 ft and height from the soil surface was 5.5 ft.

***Stress application*:** The experiment was composed of two phases. During the first phase seedlings were watered normally till one and half month old. The second phase was two-month in which salinity were applied on different levels. Firstly, the selected seeds were sown in four plastic trays ("15x9") and ground water were applied. After six weeks of germination, seedlings in three groups were shifted in pots and treated with three different level of salinity (EC) in each group, using NaCl loaded irrigation watered: 1-$T_0$ (no NaCl addition to irrigation water), 2-$T_1$ (Irrigation water of 8 EC), 3-$T_2$ (Irrigation water of 12 EC). There were 6 plants of each species per treatment per replication. Thus, total number of experimental seedlings were (species × number of plants × treatment × replication) 108. Total duration of the experiment was six months.

**Growth Parameters**

***Number of leaves*:** The numbers of leaves were counted manually from each and every individual throughout all the treatments carefully. The first leave of the entire individual was marked with permanent marker. Then repeated this activity with regular interval of 10 days.

***Stem height (cm)*:** The collar point on the base of individual was marked with permanent marker. The stem height was measured from collar point to the apex of the individual with measuring tape. Then repeated this activity with regular interval of 10 days.

***Stem diameter (mm*):** The stem diameter was measured using digital caliper (0-150mm6). Two readings were taken at collar points which were diagonal to each other.

**Biomass Production**

***Plant (fresh weight and dry weight*):** The individual plant was harvested and separated. The plant sample was placed into the paper bag and weight immediately with using weighing balance (Electronic Scale JJ3000B). After this plant sample was placed into heat oven (DGH - 9202 SERIES THERMAL ELECTRIC THERMOSTAT DRYING OVEN) at 70ºC for 48 hours. The samples were removed from the oven to measure the dry weight.

***Leaf (fresh weight and dry weight)*:** The plants were harvested and separated into different parts such as leaves, stem and roots. Leaves were placed into the paper bag and weighted immediately by using weighing balance (Electronic Scale JJ3000B). After this leave samples were placed into heat oven (DGH - 9202 SERIES THERMAL ELECTRIC THERMOSTAT DRYING OVEN) at 70ºC for 48 hours. The samples were removed from the oven and measured the dry weight.

***Stem (fresh weight and dry weight)*:** The stem of plants were harvested and separated. The stem samples were placed into the paper bag and weight immediately with using weighing balance (Electronic Scale JJ3000B). After this stem sample were placed into heat oven (DGH - 9202 SERIES THERMAL ELECTRIC THERMOSTAT DRYING OVEN) at 70ºC for 48 hours. The samples were removed from the oven and measured the dry weight.

***Root (fresh weight and dry weight*):** The roots of plants were harvested and separated. The root samples were placed into the paper bag and weighed immediately using weighing balance (Electronic Scale JJ3000B). After this root samples were placed into heat oven (DGH - 9202 SERIES THERMAL ELECTRIC THERMOSTAT DRYING OVEN) at 70ºC for 48 hours. The samples were removed from the oven and measured the dry weight.

***Statistical Analysis*:** The experiment was arranged in a factorial design. The data were analysed with a two-way ANOVA, with species, replication and treatment (salinity and control) as factors. To analyse differences between treatments, a Tukey post-hoc test was used with a "P level of 0.05". All statistical analysis were carried out using Statistica v8.1 (Statsoft, Inc., Tulsa, USA). All tests and correlation were taken as significant at $P<0.05$.

## RESULTS

***Effect of different levels of salinity on root fresh weight (g) of Eucalyptus species*:** Effect of different salinity levels on two species of *Eucalyptus* was checked. The ANOVA table shows that the root fresh weight of *Eucalyptus* seedlings under various treatments were significantly different from each other (P=0.00) (Table 3). Mean root fresh weight with SE well represented which explored on average maximum root fresh weight was noticed in control condition (5.5944 g) and minimum under higher saline condition (2.3528 g) (Table 1).

**Table 1: Comparison of treatment means for root fresh weight (g) of *Eucalyptus camaldulensis* and Eucalyptus globulus.**

| Treatment EC ($dsm^{-1}$) | Mean | S.E |
|---|---|---|
| 0 | 5.5944 A | 1.799 |
| 8 EC | 2.4889 B | 0.780 |
| 12 EC | 2.3528 B | 0.785 |

**Table 2: Comparison of both species for fresh weight (g) of root under saline conditions**

| Species | Mean |
|---|---|
| *Eucalyptus camaldulensis* | 3.8148 B |
| *Eucalyptus globulus* | 4.9426 A |

Data revealed that maximum reduction in root fresh weight was evidenced under high saline conditions. Conversely, an

**Table 3: Analysis of variance for effect of salt stress on root fresh weight (g) of *Eucalyptus camaldulensis* and Eucalyptus globulus.**

| Source | DF | SS | MS | F | P |
|---|---|---|---|---|---|
| Rep | 2 | 0.015 | 0.007 | | |
| Treatment | 2 | 242.057 | 121.028 | 148.80 | 0.0000** |
| Species | 1 | 12.201 | 12.201 | 15.00 | 0.0002* |
| Treatment*species | 2 | 10.812 | 5.406 | 6.65 | 0.0019* |
| Error | 100 | 81.337 | 0.813 | | |
| Total | 107 | 346.421 | | | |

** = Highly significant * =Significant NS =non-significant CV= 20.93

increase in root fresh weight was observed under controlled conditions. However, the progressive decrease with increasing salt concentration was evidence in both species. Comparison of both species revealed that average root fresh weight of *Eucalyptus globulus* (4.9426 g) was (1%) higher than *Eucalyptus camaldulensis* (3.8148 g (Table 2)

In species treatments interaction under salinity stress, it was revealed that in control condition root fresh weight of *Eucalyptus globulus* was (1%) higher than the *Eucalyptus camaldulensis*. Similarly, in moderate saline conditions (8 EC), root fresh weight of *Eucalyptus globulus* seedlings was (1%) also higher than the *Eucalyptus camaldulensis* and same effect was observed on higher saline conditions (12 EC) (Table 1) So it is concluded that salinity stress significantly altered root fresh weight in both species and *Eucalyptus camaldulensis* could grow best in saline conditions as compared to *Eucalyptus globulus*.

**Table 4: Effect of treatment*species on root fresh weight (g) of *Eucalyptus camaldulensis* and*Eucalyptus globulus.***

| Treatment | Species | Mean |
|---|---|---|
| 0 | *Eucalyptus camaldulensis* | 5.9333 A |
| 0 | *Eucalyptus globulus* | 6.2556 A |
| 1 | *Eucalyptus camaldulensis* | 3.2111 B |
| 1 | *Eucalyptus globulus* | 3.7667 B |
| 2 | *Eucalyptus camaldulensis* | 2.3000 C |
| 2 | *Eucalyptus globulus* | 2.4056 BC |

**Effect of different levels of salinity on root dry weight (g) of *Eucalyptus* species:** Effect of different salinity levels on two species of *Eucalyptus* was checked. The ANOVA table shows that the root dry weight of *Eucalyptus* seedlings under various treatments were significantly different from each other (P=0.00) (Table 7) Mean root dry weight with SE well represented which explored that on average maximum root dry weight was noticed in control condition (2.4861 g) and minimum under higher saline condition (1.0333 g) (Table 5). Data revealed that maximum reduction in root dry weight was evidenced under high saline conditions. Conversely, increase in root dry weight was observed under control conditions. However, progressive decrease with increasing salt concentration was evidenced in both species. Comparison of both species revealed that average root dry weight of *Eucalyptus globulus* (2.4130 g) was (1%) higher than *Eucalyptus camaldulensis* (1.5704 g*)* (Table 6).

**Table 5: Comparison of treatment means for root dry weight (g) of *Eucalyptus camaldulensis and Eucalyptus globulus.***

| Treatment EC ($dsm^{-1}$) | Mean | S.E |
|---|---|---|
| 0 | 2.4861 A | 0.804 |
| 8 EC | 1.1056 B | 0.790 |
| 12 EC | 1.0333 B | 0.800 |

**Table 6. Comparison of both species for dry weight (g) of root under saline conditions**

| Species | Mean |
|---|---|
| *Eucalyptus camaldulensis* | 1.5704 B |
| *Eucalyptus globulus* | 2.4130 A |

**Table 7: Analysis of variance for effect of salt stress on root dry weight (g) of *Eucalyptus camaldulensis and Eucalyptus globulus.***

| Source | DF | SS | MS | F | P |
|---|---|---|---|---|---|
| Rep | 2 | 0.0039 | 0.0019 | | |
| Treatment | 2 | 48.2606 | 24.1303 | 133.90 | 0.0000** |
| Species | 1 | 1.7890 | 1.7890 | 9.93 | 0.0021* |
| Treatment*species | 2 | 1.1280 | 0.5640 | 3.13 | 0.0480* |
| Error | 100 | 18.0211 | 0.1802 | | |
| Total | 107 | 69.2025 | | | |

** = Highly significant * =Significant NS =non-significant CV= 20.54

In species treatments interaction under salinity stress, it was revealed that in control condition root dry weight of *Eucalyptus globulus* was (1%) higher than the *Eucalyptus camaldulensis*. While in moderate saline conditions (8 EC) root dry weight of *Eucalyptus globulus* was (1%) higher than the *Eucalyptus camaldulensis* and same effect was observed on higher saline conditions (12 EC) (Table 5).

So, we concluded that salinity stress significantly altered the root dry weight in both species. And *Eucalyptus camaldulensis* could grow best in saline conditions as compared to *Eucalyptus globulus*.

**Table 8: Effect of treatment*species on root dry weight (g) of *Eucalyptus camaldulensis* and *Eucalyptus globulus.***

| Treatment | Species | Mean |
|---|---|---|
| 0 | *Eucalyptus camaldulensis* | 2.6222 A |
| 0 | *Eucalyptus globulus* | 3.4610 A |
| 1 | *Eucalyptus camaldulensis* | 1.3556 B |
| 1 | *Eucalyptus globulus* | 1.5630 C |
| 2 | *Eucalyptus globulus* | 1.0333 BC |
| 2 | *Eucalyptus camaldulensis* | 1.0333 BC |

***Effect of different levels of salinity on plant height (cm) of Eucalyptus species*: **Effect of different salinity levels on two species of *Eucalyptus* was checked. The ANOVA table shows that the plant height of *Eucalyptus* seedlings under various treatments were significantly different from each other (P=0.00) (Table 11). Mean plant height with SE well represented which explored that on average, maximum plant height was noticed in control conditions (63.43 cm) and minimum under higher saline condition (40.481 cm) (Table 9). Data revealed that maximum reduction in plant height was observed under high saline conditions. Conversely an increase in plant height was observed under controlled conditions. However, the progressive decrease with increasing salt concentration was evidenced in both species. Comparison of both species revealed that average height of *Eucalyptus camaldulensis* (51.452 cm) was (6%) higher than *Eucalyptus globulus* (45.233 cm*)* (Table 10).

In species treatments interaction under salinity stress, it was revealed that in control condition height of *Eucalyptus camaldulensis* was (10%) higher than the *Eucalyptus globulus*. While in moderate saline conditions (8 EC), height of *Eucalyptus camaldulensis* was (6%) also higher than the *Eucalyptus globulus* and same effect was observed on higher saline conditions (12 EC) (Table 9).

So, we concluded that salinity stress significantly altered plant height in both species and *Eucalyptus camaldulensis* could grow best in saline conditions as compared to *Eucalyptus globulus.*

**Table 9: Comparison of treatment means for plant height (cm) of *Eucalyptus camaldulensis*and *Eucalyptus globulus.***

| Treatment EC ($dsm^{-1}$) | Mean | S.E |
|---|---|---|
| 0 | 63.436 A | 13.240 |
| 8 EC | 41.111 B | 13.230 |
| 12 EC | 40.481 B | 13.236 |

**Table 10: Comparison the plant height (cm) of both species under saline conditions.**

| Species | Mean |
|---|---|
| *Eucalyptus camaldulensis* | 51.452 A |
| *Eucalyptus globulus* | 45.233 B |

**Table 12: Effect of treatment*species on plant height (cm) of *Eucalyptus camaldulensis* and *Eucalyptus globulus***

| Treatment | Species | Mean |
|---|---|---|
| 0 | *Eucalyptus camaldulensis* | 67.694 A |
| 0 | *Eucalyptus globulus* | 59.178 B |
| 1 | *Eucalyptus camaldulensis* | 43.383 C |
| 1 | *Eucalyptus globulus* | 37.578 C |
| 2 | *Eucalyptus camaldulensis* | 43.278 C |
| 2 | *Eucalyptus globulus* | 38.944 C |

## DISCUSSION

Carter *et al*. (2006) noticed more plant height in *Eucalyptus* species under controlled condition and that was progressively decreased with increase EC (salt concentration). Reduction in plant height has been demonstrated because of exerted loss of

**Table 11: Analysis of variance for effect of salt stress on plant height (cm) of *Eucalyptus camaldulensis and Eucalyptus globulus.***

| Source | DF | SS | MS | F | P |
|---|---|---|---|---|---|
| Rep | 2 | 0.04 | 0.02 | | |
| Treatment | 2 | 12309.10 | 6154.56 | 115.60 | $0.0000^{**}$ |
| Species | 1 | 1044.09 | 1044.09 | 19.61 | $0.0000^{*}$ |
| Treatment*species | 2 | 81.05 | 40.53 | 0.76 | $0.4698^{NS}$ |
| Error | 100 | 5323.79 | 53.24 | | |
| Total | 107 | 18758.10 | | | |

$^{**}$ = Highly significant * =Significant $^{NS}$ =non-significan CV= 15.09

water potential due to excessive ex-osmosis because of high salt concentration present in soil (Saqib *et al.*, 2005).

In our study, plant height (cm) of *Eucalyptus camaldulensis* was significantly higher (20%) than *Eucalyptus globulus* (59.2 cm). Plant height (cm) of *Eucalyptus camaldulensis* and *Eucalyptus globulus* were also disturbed by increasing salinity. In control condition height of both species were increased (63.43 cm) and decreased under high saline condition (40.48 cm). By comparing both species under control and salinity stress, it was found that 38% height of both species were decreased under high saline condition (12 EC) and 25% decreased under moderate saline condition (8 EC) than controlled condition. Thus,the findings are in agreement with results of Saqib *et al*. (2005) and Carter *et al*. (2006) who also noticed significant decrease in plant height of *Eucalyptus* species with progressive increase in salinity stress.

The findings of the study clearly explain that *Eucalyptus camaldulensis* has more potential to grow fast with more biomass production as compared to *Eucalyptus globulus*. No doubt, *Eucalyptus camaldulensis* has been found potentially more active in gaining plant height and grow relatively fast as compared to *Eucalyptus globulus* as the height of *Eucalyptus globulus* was only 6cm less than *Eucalyptus camaldulensis*. It doesn't mean that *Eucalyptus globulus* is found poor to be established under salinity and drought stress. In over the present study, it was found quite successful to be established under similar stress having its additional peculiar features of drought stress.

Barrett-Lennard and Shabala (2013) and Ashraf and Harris (2004) noticed more root fresh weight in *Eucalyptus camaldulensis* and *Eucalyptus occidentalis* species under controlled condition and that was progressively decreased with increasing salt concentration.

The root fresh weight (g) of *Eucalyptus globulus* was significantly higher (5%) than *Eucalyptus camaldulensis*. Root fresh weight (g) of *Eucalyptus camaldulensis* and *Eucalyptus globulus* were also decreased by increasing salinity stress. In controlled condition root fresh weight of both species were increased (5.594 g) and decreased with increasing salinity (2.352 g). About half root fresh weight of both species were decreased under high saline condition (12 EC). And 1/4$^{th}$ decreased under moderate saline condition. Thus our findings are in agreement with results of Barrett-Lennard and Shabala (2013) who also noticed significant increase in root fresh weight of *Eucalyptus* species with progressive decreased in salinity stress.

However, the findings of our study clearly explain that *Eucalyptuscamaldulensis* has more potential to grow fast with more biomass production as compared to *Eucalyptus globulus*. One thing more that which was observed during the study that the *Eucalyptuscamaldulensis* has tap root system and gaining more amount of water from land rather than *Eucalyptus globulus* having more lateral and fibrous roots as compared to *Eucalyptus camaldulensis* and used small amount of water for its growth. So, we could use *Eucalyptus globulus* for planting under arid and semi-arid regions of Pakistan as compared to *Eucalyptus camaldulensis.*

Marcar (1993) noticed more root dry weight in *Dalbergia sissoo* under controlled conditions and was progressively decreased with increasing salt concentration. Reduction in dry weight of stem has been demonstrated due to exerted loss of water potential due to excessive ex-osmosis due to the high salt concentration present in soil (Raza *et al.*, 2006).

In the study root dry weight (g) of *Eucalyptus globulus* was significantly higher (15%) than *Eucalyptus camaldulensis*. Root dry weight (g) of *Eucalyptus camaldulensis* and *Eucalyptus globulus* were also decreased by increasing salinity stress. In controlled condition root dry weight of both species were increased (2.486 g) and decreased with increasing salinity (1.033 g). About half dry weight of both species were decreased under high saline condition (12 EC) and 1/4$^{th}$ decreased under moderate saline condition. Thus our findings are in agreement with result of Marcar*et al.*(1993) and Raza *et al.*, (2006) who also noticed significantly decreased in root dry weight of *Eucalyptus* species with progressive increase in salinity stress.

***Conclusion*:** It was observed that *Eucalyptus camaldulensis* and *Eucalyptus globulus* is salt tolerant tree species in arid and semi-arid regions. Both species have maximum production of biomass in very short rotation age. There was a very little difference observed in terms of total biomass produced and it was concluded that *Eucalyptus globulus* had great potential to be used under arid and semi-arid conditions. The main difference observed between two species was of root growth and root biomass. *Eucalyptus camaldulensis* had longer roots growing vertically following lowering water table thus causing major water table loss whereas *Eucalyptus globulus* has more root biomass but root length indicating more vigorous root system with lateral root growth which will not be a major threat in lowering water table a major impediment in growing *Eucalyptus camaldulensis* globally.

## REFERENCES

Ahmad, P. 2005. *Eucalyptus camaldulensis* in agro forestry. Its effects on agricultural production and economics. Agro Forestry Systems. 8:31–4.

Antunes A., A. Maral and M.N.Belgacem. 2000. CynaracardunculusL.: chemical composition and soda-anthraquinone cooking. Industrial Crops and Products. 12:85–91.

Ashraf, M.Y., A.R. Awan and K. Mahmood. 2012. Rehabilitation of saline ecosystems through cultivation of salt tolerant plants. Pak. J. Bot. 44:69-75.

Barrett-Lennard E.G. and S.N. Shabala. 2013. The waterlogging/salinity interaction in higher plants

revisited-focusing on the hypoxia-induced disturbance to K+ homeostasis. Funct Plant Biol. 40:872-882.

Carter J.L., E.J. Veneklaas, T.D. Colmer, J. Eastham and T.J. Hatton. 2006. Contrasting water relations of three coastal tree species with different exposure to salinity. Physiol. Planta 127:360-373.

Espaola de Fabricantes de Pasta, Papel y Carto´n. Madrid. 2006. Aspapel-Asociacion, Spain), available on; www.aspapel.es.

Farrington, P. and G.A Battle. 2009. Recharge beneath a Banksia woodland and a Pinuspinoster plantation on coastal deep sands in south Western Australia. For. Ecol. Manag Eucalyptus. 40:101-118.

Khan, A.R. 2000. Forestry Resources Management. Symposium on Asian Productivity Organization (APO). Govt. of Japan, 7th –14Th Nov. pp. 284–85.

Khan, D.M.Z. and R.A. Khan. 2001. Current end uses of Eucalyptus in Punjab. J. Anim. Plant Sci.8: 47–49.

Marcar, N. E., J. Akhtar, Z. A. Saqib, R. H. Qureshi, M. A. Haq and M. S. Iqbal. 1993. Mechanisms. Annu. Rev. Plant Physiol. Plant Mol. Biol. 50:571–599.

Midgley, S.J.J.W. Tumbull and V.J. Hartney .2004. Fuelwood species for salt affected sites. Reclam. Reveg. Res. 285-303.

Mohyuddin, Q. 2007. Sustainable Production and Marketing of Wood fuel in Pakistan. In: Proc. Nat. Workshop on Woodfuel Prod. Market. inPakstan. 33–9. FAO. Bankok.

Nowak, D.J., M.H. Noble, S.M. Sisinni, and J.F. Dwyer. 2001. People and trees: Assessing the U.S. urban forest resource. J. For. 99:37–42.

Patt R, C.Kockmann, O.Kordsachia andA.Geisenheiner. 2004. Pulping of beech wood using different acid and alkaline pulping processes—a comparison. IpwIntPaperworldDasPapier. 1:41–47.

Quraishi, M.A.A. 2000. Basics of Forestry and Allied Sciences. A– One Publishers, Urdu Bazar, Lahor*Eucalyptus.* Pp. 315.

Raza, S.H., H.R. Athar and M. Ashraf. 2006. Influence of exogenously applied clycinebetaine on the photosynthetic capacity of two differently adapted wheat cultivars under salt stress. Pak. J. Bot. 38:341-351.

Saqib, M., J. Akhtar and R.H. Qureshi. 2005. Na exclusion and salt resistance of wheat (*Tricticumaestivum*) in saline-waterlogged conditions are improved by the development of adventitiousnodal roots and cortical root aerenchyma. Plant Sci.169:125-130.

Scherr, S.J., A.White and D. Kaimowitz. 2003. Making markets work for forest communities. Int. For. Rev. 5:67–73.

Trabado, G. I. and D. Wilstermann. 2008. Eucalyptus Universalis. Global Cultivated Eucalyptus Forest Map.

Zekri, M. and L.R. Parsons. 2008. Salinity tolerance of crtrus rootstocks: Effects of salt on root and leaf mineral concentrations. J. Plant Soil.147:171-181.

Ashraf, M. and P.J.C. Harris. 2004. Potential biochemical indicators of salinity tolerance in plants. Plant Sci. 166:3-16.